**Conversion Factors**

### Area
- 1 square foot = 144 square inches
- 1 square yard = 9 square feet
- 1 square mile = 640 acres or 1 section
- 1 square meter = 10.764 square feet
- 1 square meter = 10,000 square centimeters
- 1 acre = 43,560 square feet
- 1 hectare = 2.471 acres

### Length
- 1 inch = 2.54 centimeters = 25.4 millimeters
- 1 foot = 12 inches = 0.305 meters
- 1 yard = 3 feet = 0.914 meters
- 1 mile = 5,280 feet = 1,760 yards
- 1 meter = 39.37 inches = 3.281 feet
- 1 kilometer = 0.621 miles = 1,000 meters

### Weight
- 1 gallon = 8.34 pounds of water
- 1 cubic foot = 62.4 pounds of water
- 1 pound = 0.454 kilograms
- 1 kilogram = 1,000 grams
- 1 liter = 1,000 grams
- 1 mg/kg or 1 ppm or 1 mg/L = 0.00022 pounds/ton or 0.0001% / 1,000 mg/L
- 1% = 10,000 mg/L

### Volume
- 1 cubic foot = 1,728 cubic inches
- 1 cubic foot = 7.48 gallons
- 1 cubic yard = 27 cubic feet
- 1 acre-inch = 27,152 gallons
- 1 acre-foot = 326,000 gallons*
- 1 gallon = 3.785 liters
- 1 gallon = 231 cubic inches
- 1 gallon = 4 quarts
- 1 cubic meter = 35.318 cubic feet
- 1 cubic meter = 1.308 cubic yards
- 1 liter = 0.2642 gallons
- 1 liter = 1,000 milliliters

*rounded off to nearest thousand gallons

### Flow
- 1 cubic foot/second = 449 gallons/minute
- 1 gallon/second = 0.134 cubic feet/second
- 1 gallon/second = 8.021 cubic feet/minute
- 1 gallon/minute = 0.0023 cubic feet/second
- 1 gallon/minute = 1,440 gallons/day
The metric system is a decimal system based on units of tens – similar to our currency. If you think of the dollar as the basic unit, we can break it down this way:

- Dime = 0.10 dollars
- Cent = 0.01 dollars
- Mill (used in levying taxes) = 0.001 dollars

Occasionally we may want an extremely small (micro) number. If we want to talk about larger amounts – like 1000 watts of electricity – we use the prefix kilo (kilowatt). And sometimes we may need an extremely large (mega) number.

The metric system has three basic units of measurement:

- **Length** is measured in meters.
- **Volume** is measured in liters.
- **Weight** (mass) is measured in grams.

Like dollars, each can be broken into smaller units and expanded into larger units as shown in Table 1. (The most commonly used units are bolded.)

### Table 1: Comparing the Metric System

<table>
<thead>
<tr>
<th>Basic Unit</th>
<th>Symbol</th>
<th>Prefix</th>
<th>Micro</th>
<th>Milli</th>
<th>Centi</th>
<th>Deka</th>
<th>Hecto</th>
<th>Kilo</th>
<th>Mega</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000</td>
<td>1,000,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.000001</td>
<td>0.001</td>
<td>0.01</td>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dollar</td>
<td>Watt</td>
<td>Kilowatt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meter</td>
<td>Kilometer</td>
<td>Megameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Millimeter</td>
<td>Centimeter</td>
<td>Decimeter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micrometer</td>
<td>Milliliter</td>
<td>Centiliter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microliter</td>
<td>Milligram</td>
<td>Centigram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microgram</td>
<td>Gram</td>
<td>Kilogram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micrometer</td>
<td>Millimeter</td>
<td>Decimeter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microliter</td>
<td>Milliliter</td>
<td>Deciliter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microgram</td>
<td>Milligram</td>
<td>Decigram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One other useful term is a measurement of area. A square of land measuring 100 meters by 100 meters is called a hectare, after the prefix for 100 – hecto.

### Table 2: Prefixes used in the Metric System

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Meaning</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro</td>
<td>0.000001</td>
<td>1/1,000,000</td>
</tr>
<tr>
<td>Milli</td>
<td>0.001</td>
<td>1/1,000</td>
</tr>
<tr>
<td>Centi</td>
<td>0.01</td>
<td>1/100</td>
</tr>
<tr>
<td>Deci</td>
<td>0.1</td>
<td>1/10</td>
</tr>
<tr>
<td>Deka</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Hecto</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Kilo</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Mega</td>
<td>1,000,000</td>
<td></td>
</tr>
</tbody>
</table>

### Trivia:

- A centimeter is about the width of your little finger.
- The “hand” (used for measuring horses) is about 10 centimeters, or a decimeter.
- By the original definition of the meter in the eighteenth century, the circumference of the earth is 40 megameters.

### Symbols & Abbreviations

- **Symbols**
  - $\pi$ = pi or 3.14
  - $\alpha$ = per (as gallons/day)
  - $\%$ = percent
  - $\mu$L = microliters

- **Abbreviations**
  - hr = hour
  - HRT = hydraulic retention time
  - in = inch
  - $in^2$ = square inch
  - $in^3$ = cubic inch
  - L = length or liter
  - lb = pound
  - mi = mile
  - $mi^2$ = square mile
  - min = minute
  - mg = milligrams
  - mg/kg = milligrams per kilogram
  - mg/L = milligrams per liter
  - Mgal or MGD = million gallons
  - MG = million gallons
  - MGD = million gallons per day
  - ml = milliliters
  - MLSS = mixed liquor suspended solids
  - MLVSS = mixed liquor volatile suspended solids
  - N = nitrogen
  - NH$_3$N = ammonia nitrogen
  - NO$_2$ = nitrite
  - NO$_3$ = nitrate
  - Org. N = organic nitrogen
  - P = perimeter
  - PE = population equivalent
  - $pi$ or $\pi$ = 3.14

- **Abbreviations**
  - ppm = parts per million
  - ppb = parts per billion
  - psi = pounds per square inch
  - Q = flow
  - R = radius
  - RPM = revolutions per minute
  - run = horizontal distance or length
  - S = side of a rectangle
  - sec = seconds
  - sq in = square inches
  - sq ft = square feet
  - SVI = sludge volume index
  - TSS = solids retention time
  - SS = suspended solids
  - TKN = Total Kjeldahl Nitrogen
  - TSS = total suspended solids
  - V or vol = volume
  - vel = velocity
  - W = width
  - WAS = waste activated sludge
  - yr = year

©2017, State of Minnesota, Minnesota Pollution Control Agency
All rights reserved.
**Stabilization Ponds/Spray Irrigation**

**Organic Loading on Primary Cell(s) (pounds per day per acre) =**

\[
influent \text{ BOD (mg/L)} \times \text{flow (MGD)} \times 8.34 \text{ lbs/gallon} \]
\[
\text{total surface area of primary(s) (acres)}
\]

**Storage Volume of a Pond (gallons) =**

\[
\text{average surface area (acres)} \times \text{depth (feet)} \times 326,000 \text{ gallons per acre-feet}
\]

**Volume of Pond Discharged (gallons) =**

\[
\text{depth discharged (feet)} \times \text{pond size (acres)} \times 326,000 \text{ gallons per acre-feet}
\]

**Discharge Flow Rate (gallons per day) =**

\[
\text{depth discharged in one day (feet per day)} \times \text{pond size (acres)} \times 326,000 \text{ gallons per acre-feet}
\]

**Detention Time = volume of pond between maximum and minimum depth \text{ flow rate}**

**Total Feet Needed to Discharge or Spray:**

1. **Storage volume needed (acre-feet) =**

\[
\text{flow rate (gallons per day)} \times \text{storage time needed (days)} \div 326,000 \text{ gallons per acre-feet}
\]

2. **Storage volume available (acre-feet) =**

\[
[\text{maximum depth (feet)} – \text{actual depth (feet)}] \times \text{size of pond (acres)}
\]

3. **Total volume needed to discharge or irrigate (acre-feet) =**

\[
\text{storage volume needed (acre-feet)} – \text{storage volume available (acre-feet)}
\]

4. **Total feet needed to discharge or spray (feet) =**

\[
\text{total volume needed to discharge or spray (acre-feet)} \div \text{size of pond being discharged or sprayed (acres)}
\]

**Digestion**

**Volatile Acid/Alkalinity Ratio =**

\[
\text{volatile acids concentration (ml/L)} \div \text{alkalinity concentration (ml/L)}
\]

**Total Solids Loading (lbs/day) =**

\[
\text{percent total solids} \times \text{raw sludge (gal/day)} \times 8.34 \text{ (lbs/gal)} \div 100
\]

**Volatile Solids Loading (lbs/day) =**

\[
\text{percent volatile solids} \times \text{total solids loading (lbs/day)} \div 100
\]

**Volatile Solids Loading (lbs VS/cu ft of digester capacity) =**

\[
\text{volatile solids loading (lbs/day)} \div \text{digester volume (cu ft)}
\]

**Dry tons =**

\[
\text{gallons} \times \text{percent total solids} \div 240
\]

**Perimeter /Circumference**

- **Rectangle or Square**
  \[P = S_1 + S_2 + S_3 + S_4\]

- **Circle**
  \[C = \pi \times D\]
  \[(The \ diameter \ is \ two \ times \ the \ radius: \ D = 2 \times R)\]

- **Area**
  \[A = L \times W\]
  \[A = 0.785 \times D^2\]
  \[A = \pi \times R^2\]
  \[(The \ area \ of \ a \ circle \ is \ equal \ to \ 0.785 \ times \ the \ Diameter \ squared \ (D^2)).\]
  \[(Area \ (A) \ of \ a \ circle \ is \ also \ equal \ to \ pi \ (\pi, \ 3.14) \ times \ the \ Radius \ squared \ (R^2).)\]
  \[A = \pi \times R^2\]
  \[(Remember: \ the \ diameter \ is \ two \ times \ the \ radius: \ D = 2 \times R)\]

- **Triangle**
  \[A = \frac{1}{2} \times \text{base} \times \text{height}\]
  \[A = \frac{1}{2} \times \text{base} \times \text{height}\]

**Perimeter and Circumference Formulas:**

- **Perimeter (P)** is the sum of the four sides (S).
- **Circumference (C)** is \(\pi\) (3.14) times the diameter (D).
  \[(The \ diameter \ is \ two \ times \ the \ radius: \ D = 2 \times R)\]

**Area Formulas:**

- **Rectangle or Square**
  \[A = L \times W\]
  \[A = 0.785 \times D^2\]
  \[A = \pi \times R^2\]
  \[(The \ area \ of \ a \ circle \ is \ equal \ to \ 0.785 \ times \ the \ Diameter \ squared \ (D^2)).\]
  \[(Area \ (A) \ of \ a \ circle \ is \ also \ equal \ to \ pi \ (\pi, \ 3.14) \ times \ the \ Radius \ squared \ (R^2).)\]
  \[A = \pi \times R^2\]
  \[(Remember: \ the \ diameter \ is \ two \ times \ the \ radius: \ D = 2 \times R)\]

**Triangle**

\[A = \frac{1}{2} \times \text{base} \times \text{height}\]
Volume

**Rectangle**

The Volume \((V)\) of a rectangle equals its Area \((A)\) times its Height \((H)\).

\[ V = A \times H \]

Since the Area \((A)\) of a rectangle is its Length \((L)\) times its Width \((W)\), Volume \((V)\) can also be expressed as Length \((L)\) times Width \((W)\) times Height \((H)\).

\[ V = L \times W \times H \]

**Cylinder**

The Volume \((V)\) of a cylinder equals its Area \((A)\) times its Height \((H)\).

\[ V = A \times H \]

Since its Area \((A)\) equals 0.785 times the Diameter squared \((D^2)\), Volume \((V)\) equals 0.785 times the Diameter squared \((D^2)\) times its Height \((H)\).

**Cone**

The Volume \((V)\) of a cone equals its Area \((A)\) times its Height \((H)\) divided by 3.

\[ V = \frac{A \times H}{3} \]

To convert volume from cubic feet to gallons: multiply cubic feet x 7.48 gallons per cubic feet

If using goal posts to convert cubic feet to gallons, use the factor

\[
\text{cubic ft} = \frac{7.48 \text{ gallons}}{1 \text{ cubic ft}}
\]

Hydraulic Loading Rate

\[
\text{HLR (in gallons per day per square foot) = \frac{\text{flow rate (gallons/day)}}{\text{total surface area of media (square feet)}}}
\]

Organic Loading Rate

\[
\text{OLR (in pounds per day per 1,000 sq ft) = \frac{\text{pounds/day applied to RBC}}{\text{total surface area of media (in 1,000 sq ft units)}}}
\]

To convert gallons/day to million gallons per day:

\[
\text{Million Gallons/Day (MGD) = \frac{\text{gallons/day}}{1,000,000}}
\]

Organic Loading

\[
\text{(in pounds per day per 1,000 cubic feet) = \frac{\text{CBOD concentration} \times \text{flow (MGD) x 8.34 lb/gal}}{\text{aeration tank volume (in 1,000 cubic feet units)}}}
\]

Food to Mass Ratio (F/M)

\[
\text{F/M} = \frac{\text{CBOD concentration}^* \times \text{flow (MGD) x 8.34 lb/gal}}{\text{MLVSS concentration (mg/L) x aeration tank volume (MG) x 8.34 lb/gal}}
\]

Sludge Volume Index (SVI)

\[
\text{SVI} = \frac{30\text{-minute sludge settleability reading (ml)}}{\text{MLSS (mg/L)}} \times 1,000
\]

SRT (Solids Retention Time)

\[
\text{SRT (days) = \frac{\text{MLVSS concentration (mg/L) x total volume** (MG) x 8.34 lb/gal}}{\text{waste sludge conc (mg/L) x waste sludge flow (MGD) x 8.34 lb/gal} + [\text{effluent TSS conc (mg/L) x flow (MGD) x 8.34 lb/gal}]} \times \frac{8.34 \text{ lb/gal}}{1,000}}
\]

Wasting Rate

\[
\text{Wasting Rate (lbs/day) = \frac{\text{MLVSS in aeration tank and clarifier (lbs)}}{\text{SRT (days)}} - \text{TSS lost (lbs/day)}}
\]

Return Rate

\[
\text{Return Rate (MGD) = \frac{\text{Total flow (MGD) x MLSS concentration (mg/L) - RAS conc (mg/L) - MLSS conc (mg/L)}}{\text{RAS conc (mg/L) - MLSS conc (mg/L)}}}
\]
Solids

Total Solids (%) = weight of dry sludge x 100
weight of wet sludge

Total Suspended Solids (mg/L) = weight of suspended solids (mg)
volume of sample (liter)

Volatile Solids (%) = weight of material lost by burning x 100
weight of dry sludge

Volatile Suspended Solids (mg/L) = weight of material lost by burning (mg)
volume of sample (liter)

Organic Nitrogen = Total Kjeldahl Nitrogen (TKN) – Ammonia Nitrogen

Clarifiers

Surface Settling Rate (SSR) = flow rate
surface area

Weir Overflow Rate (WOR) = flow rate
weir length

Detention Time (DT) = volume of tank
flow rate to or from tank

Percent Removal (PR%) = influent - effluent x 100
influent

Trickling Filter

Hydraulic Loading Rate (HLR) = total flow to filter*
surface area of filter
(*where total flow = influent flow + recirculation flow)

Organic Loading Rate (OLR) = pounds per day applied to the filter
OLR – in pounds per day per 1,000 cu ft
volume of filter media (in 1,000 cubic feet units)

Recirculation Ratio (RR) = Recirculated flow
Influent flow

Slope

Slope equals the Rise or Drop (elevation) divided by the Run (distance).

To change Fahrenheit to Celsius:
• Subtract 32 from the Fahrenheit temperature
• Divide the answer by 9.
• Multiply that answer by 5.

To change Celsius to Fahrenheit:
• Multiply the Celsius temperature by 9.
• Divide the answer by 5.
• Add 32.

Velocity/Flow Rate

Velocity = Distance traveled
Time

Flow rate = Velocity x Area

Temperature

Detention Time = volume of tank
flow rate to or from tank

%C = (°F − 32) x 5
9

°F = (°C x 9) + 32
5
Water Horsepower = Flow (gallons per minute) x Total dynamic head (feet) / 3,960

Brake Horsepower = Water horsepower / Pump efficiency*

* Expressed as a decimal, i.e., 85% = .85

Note: Horsepower = kilowatts x 1.34
Kilowatts = horsepower x 0.75

Pumping Rate & Power

Total Static Head (feet) = Static discharge head (feet) + Static suction head (feet)
Total Dynamic Head (feet) = Total static head (feet) + System friction loss or head (feet)

Chlorination & Chemicals

Chlorine Dosage (mg/L) = chlorine demand (mg/L) + chlorine residual (mg/L)

Feed Rate (lb/day) = dosage (mg/L) x flow (million gallons/day) x 8.34 lb/gallon

Chemical Dosage (lbs) = Concentration (mg/L) x Volume (MG) x 8.34 (lb/gallon)

Detention Time = volume of tank / flow rate to or from tank

Percent Removal

Percent Removal (%) = influent - effluent x 100 / influent

To calculate the Geometric Mean (GM):
1. Change all single digit “0” to “1”; drop all “<” symbols; and count the number of values you have. (For any “TNTC” values, contact lab for maximum number.)
2. Multiply all numbers.
3. Use one of these methods to find the Geometric Mean:
   - If you multiplied two numbers: push the square root key once; answer shown is the GM.
   - If you multiplied four numbers: push the square root key twice; answer shown is the GM.
   - If you multiplied three or more than four numbers: push the y^x or x^y or ^ key, then enter the inverse of the number of values you multiplied (see Table 3). Finally, push the = key; answer shown is the GM.

Table 3: Conversion of Numbers Multiplied to Its’ Inverse

<table>
<thead>
<tr>
<th>Numbers multiplied</th>
<th>Inverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.500</td>
</tr>
<tr>
<td>3</td>
<td>0.333</td>
</tr>
<tr>
<td>4</td>
<td>0.250</td>
</tr>
<tr>
<td>5</td>
<td>0.200</td>
</tr>
<tr>
<td>6</td>
<td>0.167</td>
</tr>
<tr>
<td>7</td>
<td>0.143</td>
</tr>
<tr>
<td>8</td>
<td>0.125</td>
</tr>
<tr>
<td>9</td>
<td>0.111</td>
</tr>
<tr>
<td>10</td>
<td>0.100</td>
</tr>
<tr>
<td>11</td>
<td>0.091</td>
</tr>
<tr>
<td>12</td>
<td>0.083</td>
</tr>
<tr>
<td>13</td>
<td>0.077</td>
</tr>
<tr>
<td>14</td>
<td>0.071</td>
</tr>
<tr>
<td>15</td>
<td>0.067</td>
</tr>
</tbody>
</table>

Table 4: Population equivalent factors

<table>
<thead>
<tr>
<th>Population equivalent factors</th>
<th>Bod</th>
<th>Tss</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>0.17 lb/person/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>0.20 lb/person/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow</td>
<td>100 gallons/person/day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Loading

Loading (lb/day) = concentration (mg/L) x flow (million gallons/day) x 8.34 lb/gallon

Loading (kg/day) = concentration (mg/L) x flow (million gallons/day) x 3.78 kg/gallon

Loading ORGANIC (lb/day) = population (people) x population equivalent factor (lb/person/day)

Loading HYDRAULIC (gal/day) = population (people) x population equivalent factor (gal/person/day)

Table 4: Population equivalent factors

<table>
<thead>
<tr>
<th>Population equivalent factors</th>
<th>Bod</th>
<th>Tss</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>0.17 lb/person/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>0.20 lb/person/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow</td>
<td>100 gallons/person/day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Loading (lbs) = Concentration (mg/L) x Volume (million gallons) x 8.34 lb/gallon

Loading (lbs) = Percent solids (expressed as a decimal) x Volume (gal) x 8.34 lb/gallon

Loading VOLATILE SOLIDS (lbs) = Total solids* x Volatile solids* x Volume (gal) x 8.34 lb/gallon

*expressed as a decimal